Factors Affecting the Diffusion of the Computer-Based Patient Record

Joan S. Ash, Ph.D, M.L.S., M.B.A.
Biomedical Information Communication Center
Oregon Health Sciences University
Portland, Oregon 97201-3098

A survey of the perceptions of 629 informatics experts representing 67 institutions with accredited schools of medicine was used to identify factors most important in implementing the Computer-Based Patient Record. A model outlined three theoretical factors: Innovation Attributes (attributes inherent in the CPR itself); Organizational Attributes; and Boundary-Spanning Attributes (related to marketing efforts). The model was explored using multiple regression techniques to delineate the relative importance of 15 variables within the three sets of factors and their effect on two measures of diffusion. The two dependent variables were internal diffusion, or spread of usage of the CPR, and infusion, or depth of usage. Data from the 144 respondents indicate that for diffusion, the organizational variables of "decision making" and "planning" had a significant impact, although the relation between "planning" and diffusion was negative. For infusion, the Innovation Attributes variable "visibility" was significant. The major implication is that successfully encouraging usage of the CPR entails attention and resources devoted to managing the organizational aspects of implementation.

INTRODUCTION

The Computer-Based Patient Record (CPR) is defined as "an electronic patient record that resides in a system specifically designed to support users by providing accessibility to complete and accurate data, alerts, reminders, clinical decision support systems, links to medical knowledge, and other aids" [1]. The CPR exists in many forms and is under continuous revision and development. The present study attempts to solidify some of our knowledge about the CPR by defining different levels of development and by looking at the factors which might have an impact on successful implementation. Successful implementation is critical: "CPR systems have a unique potential to improve the care of both individual patients and populations" [2].

Three theoretical factors provide the framework for this study. The first is diffusion of innovations theory (DOI), which began to be developed within several disciplines in the 1930's. Rogers, in the latest edition of his classic volume on the subject, defines diffusion as "the process by which an innovation is communicated through certain channels over time among members of a social system [3]. Innovation attributes outlined by Rogers include relative advantage (how much better it is than its predecessor), compatibility (is it consistent with existing values of potential users?), complexity, trialability, and observability [4]. A basic tenet of DOI, and one that has withstood the scrutiny of research efforts, is that attributes inherent in the innovation itself will impact the diffusion of that particular innovation. DOI theory is being tested and modified with increasing interest in relation to information technology. Two innovation attributes added to Rogers' list by information technology researchers include voluntariness of usage (do authorities demand its use?) and image (does usage increase the social status of the individual?) [5]. The term complexity has been changed to "ease of use" by many researchers, especially those studying individual acceptance of information technology innovations within the framework of the Technology Acceptance Model (TAM) [6].

The second theory upon which this study is based is organizational behavior theory. While most of Rogers' work focused on individuals, later studies introduced the complexities of studying diffusion of innovations in organizations. Organizations are more than a collection of individual adopters. Leaders can adopt an innovation for the entire organization, but usage is usually an individual decision. If management supports a culture of innovativeness with resources and attention, one expects greater success in implementing new projects [7].

A third factor of interest to diffusion researchers has been management of the boundary between the sellers and the buyers of an innovation: boundary-spanning. In marketing studies, this generally means the import and export of information across organizational boundaries, between the sales force and customers [8]. In the present context, it means the boundary between those implementing the technology and the users. Kimberly studied hospital adoption of innovations as it relates to external environments, concluding that organizations that make a real commitment to drawing in information from outside foster adoption of innovations [9].

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The aim of this study was to select variables representing Innovation Attributes, Organizational Attributes, and Boundary-Spanning Attributes and to measure their effect on the diffusion of the CPR within institutions.

METHOD

The basic research design of this study followed a procedure used previously by innovation researchers [10,11,12]. The population, the variables, and the innovation are unique, however. Organizations were the main focus, but they were viewed through the perspective of the individuals who work within them.

Selection of the Variables

Innovation diffusion has been measured in so many different ways that Fichman has actually presented a taxonomy of diffusion measures into which most studies seem to fit [13]. Because of the complexity of the CPR, both the breadth and depth of diffusion are appropriate measures. Breadth was measured using an internal diffusion measure developed by Zmud [14]. Tailored for this study, it assessed perceptions of respondents about whether:

- fewer than 25% of clinicians use the CPR regularly,
- between 26% and 50% regularly use it,
- between 51% and 75% regularly use it,
- or over 75% regularly use it.

Infusion was selected as the measure of depth of usage. Infusion is defined as "the extent to which the full potential of the innovation has been embedded within an organization's operational or managerial work systems" [15]. It is measured on a scale of increasing sophistication. The scale developed for the present study has four levels:

- No CPR modules have been implemented to date,
- Some departmental clinical information systems (lab, radiology, pharmacy, nursing) with some use by individuals outside the department are in place. An example is a laboratory information system that has a physician query terminal on the wards. [A billing or hospital information system not used by physicians or other care providers is prior to this level and does not count.],
- A system that captures and stores significant data about the clinical encounter itself is in place. Examples are diagnosis/problem lists, medication lists, and symptoms and signs. Also at the medium level is an organization that has an institution-wide network with access to one or two departmental systems,
- An integrated repository of information from a wide variety of departmental and clinical systems has been implemented. It includes decision support systems for clinicians and forms a foundation for a) the eventual electronic medical record and b) a network with workstation access to a wide variety of departmental and clinical systems.

Selection of the independent variables was guided by literature on past studies and by a qualitative interview study using oral history techniques [16]. The Innovation Attributes set included voluntariness (the degree to which usage is made mandatory by managers), result demonstrability (the degree to which results of using the innovation are apparent), personal image enhancement effects (the degree to which usage increases the social status of the individual), ease of use (the degree to which minimum physical or mental effort is needed to use the innovation), and visibility (the degree to which the innovation can be readily seen). The Organizational Attributes set included participative decision making practices (using appropriate people throughout the organization as decision makers), communication frequency (the perceived amount of communication taking place within and among levels of employees within an organization and with colleagues outside the organization), management support for innovation (the extent to which management within an organization provides moral and resource support for new ideas), planning emphasis (the extent to which appropriate project management planning techniques were used prior to implementing an innovation), and effectiveness of the reward structure (attractiveness and appropriateness of the reward structure for employees). The Boundary-Spanning Attributes variables were chosen to represent involvement and participation of end users in the implementation process: marketing intelligence generation (the collection of user needs and preferences); marketing intelligence dissemination (the process of distributing this information within the organization); marketing responsiveness (action that is taken in response to the generation and dissemination of marketing intelligence); relative advantage (the degree to which the innovation is better than other options); and compatibility (the degree to which the innovation is perceived to be consistent with the values and needs of the users).

Operationalization of the Variables

Many of the variables selected have been studied before in other contexts and questions making up scales for these

were modified. Innovation Attributes were measured using scales adapted from those developed by Moore and Benbasat [17]. Organizational Attributes were measured with scales from several sources. The communication frequency scale was a modification based on a section of the Minnesota Innovation Survey [18]. The index for participative decision making practices was modified from that in the Survey of Organizations [19]. The questions concerning management support for innovation have been taken in large part from the Siegel Scale of Support for Innovation (SSSI) [20]. The scale for effectiveness of the reward structure has been modified from the Test of an Effective Reward System developed by von Glinow for high technology personnel [21]. Boundary-Spanning Attributes were measured using scales from Moore and Benbasat [22] and Kohli et al. [23].

Survey

The survey included 78 questions related to the CPR plus six questions about the respondent. It was mailed to all AMIA members listed in the AMIA directory who had addresses affiliated with one of the 67 institutions randomly selected from among the 123 institutions with accredited schools of medicine within the U.S. The response rate was 31%, with 194 responding. Follow-up was done using electronic mail and post cards. Electronic mail was particularly effective, increasing the initial response by 73%.

Analysis

Data from individuals within institutions were aggregated so analysis could be done at the organizational level. Six regression analyses were performed, one each for diffusion and infusion related to each of the three sets of attributes.

RESULTS

The internal consistency of each scale was verified using Cronbach's coefficient alpha (see Table 1). Most were higher than .70 and fully acceptable. Visibility had a questionable alpha of .39.

TABLE 1: Descriptive Statistics

Dependent Variables (1 to 4 scale, low to high)	Alpha	N	Mean	SD	Min	Max
CPR Infusion		60	2.22	.76	1.00	4.00
CPR Diffusion		50	2.72	.85	1.00	4.00
Independent Variables (1 to 5 scale, low to high)						
Innovation Attributes Variables						
Voluntariness	.70	47	2.80	.78	1.00	4.70
Image	.86	48	2.73	.83	1.00	5.00
Ease of use	.80	48	2.56	.76	1.00	3.67
Result demonstrability	.76	48	3.45	.72	1.67	5.00
Visibility	.39	51	2.69	.75	1.50	4.67
Organizational Attributes Variables						
Communication	.70	65	3.74	.37	2.60	4.60
Decision making	.76	65	3.48	.55	2.50	5.00
Support	.90	65	3.24	.49	2.21	4.43
Planning	.58	64	3.27	.38	2.40	4.50
Rewards	.90	63	2.56	.42	1.70	3.90
Boundary-Spanning Attributes Variables						
Relative Advantage	.89	49	3.60	.75	1.50	5.00
Compatibility	.80	46	2.82	.68	1.70	4.00
Generation of marketing intelligence	.77	64	3.28	.44	2.33	4.33
Dissemination of marketing intelligence	.81	62	3.12	.46	2.20	4.40
Responsiveness of marketing	.85	63	3.41	.39	2.50	4.56

TABLE 2: Results of Regression Analyses

CPR Infusion

Innovation Attributes

Variable	beta	p
Voluntariness	-.10	.42
Image	-.21	.12
Ease of use	.10	.49
Result demonstrability	.08	.61
Visibility*	.42	.01

R sq. = .30*
Set is significant at p<.05

Organizational Attributes

Variable	beta	p
Communication	-.26	.08
Decision Making	.09	.65
Support	-.11	.60
Planning	-.01	.96
Rewards*	.38	.02

R sq. = .15
Set is not significant at p<.05

Boundary-Spanning Attributes

Variable	beta	p
Relative advantage	.12	.57
Compatibility	.16	.44
Generation of mktg.	.21	.42
Dissemination of mktg.	-.32	.27
Responsiveness to mktg.	.22	.44

R sq. = .16
Set is not significant at p<.05

CPR Diffusion

Innovation Attributes

Variable	beta	p
Voluntariness	-.02	.90
Image	-.24	.17
Ease of use	.11	.60
Result demonstrability	-.08	.69
Visibility	.28	.18

R sq. = .10
Set is not significant at p<.05

Organizational Attributes

Variable	beta	p
Communication	.36	.05
Decision making*	.63	.01
Support	-.40	.09
Planning*	-.61	.00
Rewards	.24	.20

R sq. = .30*
Set is significant at p<.05

Boundary-Spanning Attributes

Variable	beta	p
Relative advantage	-.25	.31
Compatibility	.40	.10
Generation of mktg.*	-.37	.23
Dissemination of mktg.	.13	.69
Responsiveness to mktg.	.23	.48

R sq. = .12
Set is not significant at p<.05

Pearson's correlation coefficients indicated that variables within each of the three sets had acceptable correlations below .75, the only exception being relative advantage and compatibility at .79. Interestingly, the correlation between the two dependent variables, infusion and diffusion, was -.03, indicating that the questions are indeed measuring different things. Variability among institutions for each variable was checked to assure that enough existed for statistical purposes. Table 1 indicates the mean, standard deviation, and minimum and maximum average for any institution for all variables and good variability was verified. Table 2 shows the results of the six regressions. R^2 in each case indicates the amount of variance explained by the model. At a level of significance of $p<.05$, two of the sets were significant: Innovation Attributes related to infusion and Organizational Attributes related to diffusion. Visibility was the only significant individual variable in the first significant set and the alpha for visibility was low at .39, so this result is problematic. The variables representing participative decision making and planning explained a significant amount of variance in the dependent variable diffusion. However, as indicated in Table 2 by its beta value, planning was negatively related to diffusion.

CONCLUSIONS

Innovation Attributes are important predictors of CPR infusion, with visibility a significant variable. People need to see both the system itself and other people using the system.

Organizational Attributes, especially decision making and planning, are important predictors of internal diffusion of the CPR within organizations. One explanation for the negative relation between planning and diffusion may be that careful planning takes time and diffusion is thus impeded. The particular set of questions about planning had as its focus project management planning, so questions related to strategic planning may have produced different results. The significance of participative decision making points to a need for involving clinicians and other users throughout the implementation process. This study provides empirical support for the phenomenon Massarro described so well when relating the Virginia experience: "We learned that information technologies of the scope and invasiveness of an MIS are not culturally neutral. The system was viewed by many as a threat to the values of the organization, and their responses to this cultural assault were predictable. Responses of this magnitude should be anticipated, and they must be managed." [24].

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